

# The Halden Reactor Project:

## Nuclear safety through international cooperation



U.S. Nuclear Regulatory Commission

### Background

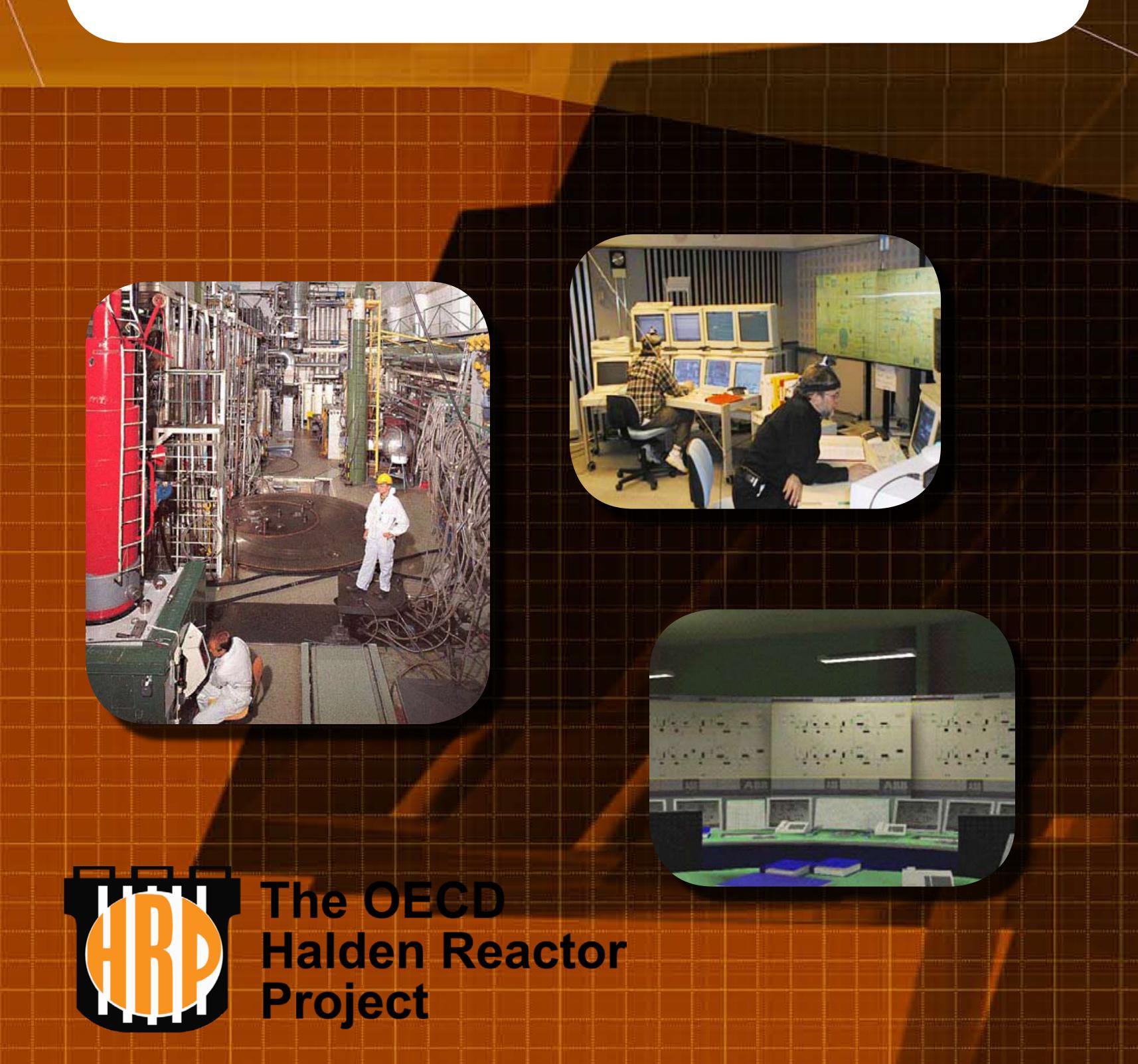
The NRC and its predecessor have participated in the Halden Reactor Project since its inception in 1958. The NRC uses products and information generated by the HRP to develop and extend the applicability of analytical tools and as the technical basis for regulatory positions.

### Facilities

The Halden Boiling Water Reactor, one of the most versatile test reactors in the world, operates at 18 to 20 MW and is contained within a mountain in Halden, Norway. The reactor is fully dedicated to instrumented in-reactor testing of fuel and reactor materials.

The **HAMMLAB** simulated control room is reconfigurable and highly automated, and thus one of the most comprehensive facilities in the world for performing experimental research on issues regarding the human-system interfaces for advanced technology in NPP control rooms.

The HRP has a world-class capability in the area of virtual and augmented environments, useful for control room design, outage planning, training, decommissioning, and research.



### Regulatory applications

#### **Nuclear fuels**

In-pile LOCA test data of high interest to effort to revise cladding embrittlement criteria in 10 CFR 50.46

Experimental data demonstrated the adequacy of the FRAPCON-3 code used by NRC staff to calculate detailed fuel rod behavior.

Halden fuel centerline thermocouple data presented during the hearing on Duke Energy's proposal to use mixed-oxide (MOX) lead test assemblies at the Catawba reactor

#### **Nuclear reactor materials**

Environmentally-assisted degradation of PWR and BWR internals, components, and piping

#### Instrumentation & controls

Realistic safety decisions pertaining to software-based digital systems, e.g., approved a predictive approach proposed by EPRI for online monitoring for calibration reduction

#### **Human factors**

HAMMLAB research and experiments provided technical basis for regulatory guidance on alarm systems, computerized procedures, hybrid control rooms, display navigation, control room staffing, and measures of human performance

Study on staffing for advanced reactors served as a basis for NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements of 10CFR 50.54(m)."

### **Human reliability**

Insights for future revisions of NUREG-1792, "Good Practices for Implementing Human Reliability Analysis (HRA)" Simulator experiments and data that can be applied to HRA modeling and quantification issues

### Research programs for next 3 years

### **Nuclear fuels**

Fuel high-burnup capabilities in normal operating conditions

Fuel response to transients

Fuel reliability issues

### **Nuclear reactor materials**

BWR materials degradation

In-core IASCC crack initiation and crack growth rate tests

### Instrumentation & controls

Software systems dependability issues related to the engineering and architecture of digital safety systems

Core monitoring, condition monitoring of electrical cables, early fault detection, optimization of plant performance and maintenance, and computerized procedures

#### **Human Factors**

Investigate the context concept, task complexity factors, and sustained workload as a performance shaping factor to provide data for the estimation of probabilities of human failure events for post-accident operation

### **Human Reliability Analysis**

Simulator experiments to collect data that can be applied to human reliability analysis modeling and quantification issues Crew characteristics

### Participating organizations

Belgium: Nuclear Research Centre (SCK CEN)

Bulgaria: Bulgarian Nuclear Regulatory Authority (BNRA)

Czech Republic: Nuclear Research Institute (NRI)

Denmark: Risø National Laboratory (Risø)

Finland: Ministry of Trade and Industry

France: Electricité de France (EdF)

Germany: Gesellschaft für Reaktorsicherheit (GRS)

Hungary: Hungarian Academy of Sciences - Atomic Energy Research Institute

Japan: Japan Atomic Energy Agency (JAEA)

Norway: Institutt for energiteknikk (IFE)

Republic of Korea: Korea Atomic Energy Research Institute (KAERI)

Russia: Russian Research Centre "Kurchatov Institute"

Slovak Republic: Nuclear Power Plant Research Institute (VUJE)

Spain: Centro de Investigaciones Energéticas, Medioambientales y Tecnologí

Sweden: Swedish Nuclear Power Inspectorate (SKI)

Switzerland: Federal Nuclear Safety Inspectorate (HSK)

United Kingdom: British Energy plc

United Kingdom: Health and Safety Executive (HSE)

USA: Office of Nuclear Regulatory Research (at USNRC)

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### For more information

http://www.nea.fr/html/jointproj/halden.html